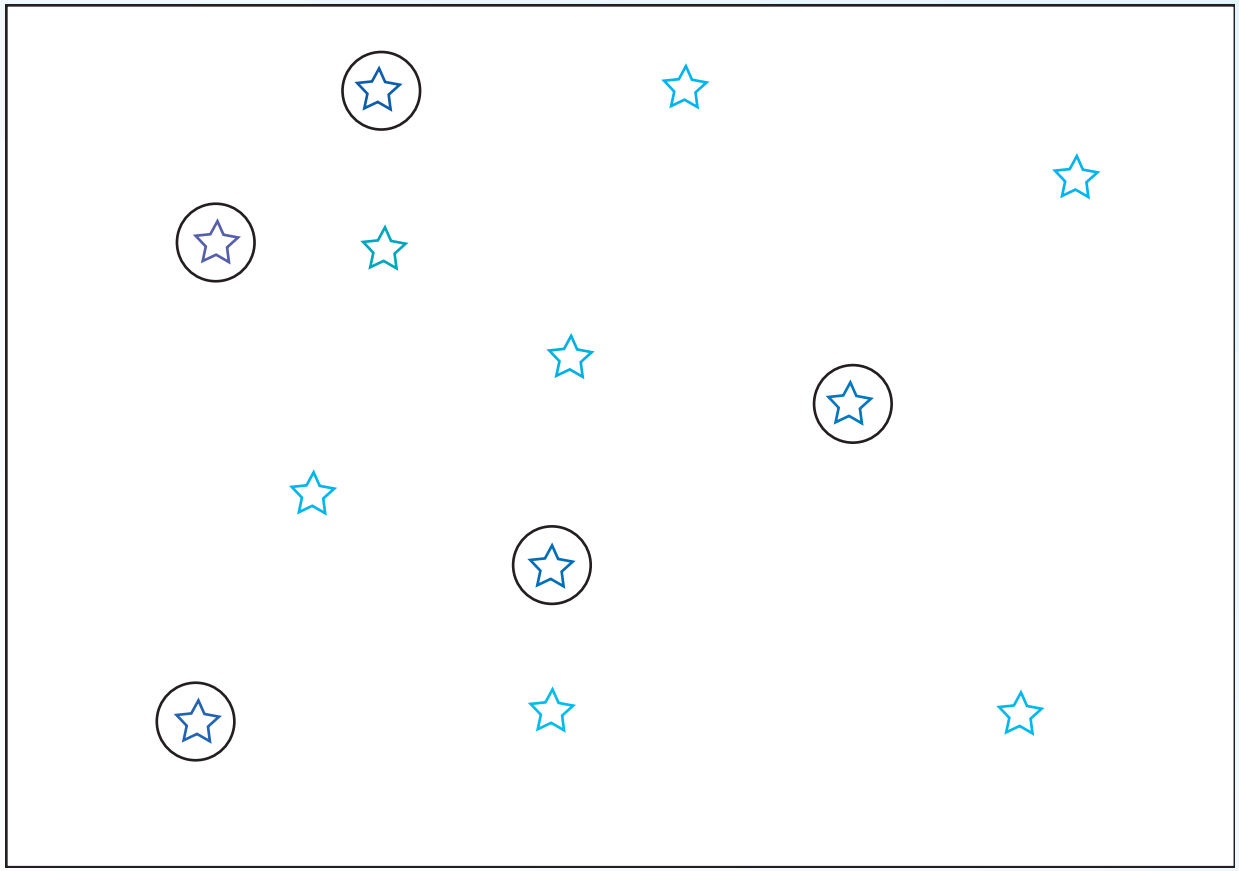
Large-format microshutter arrays for JWST NIRSpec

H. Moseley for the NIRSpec Microshutter Team

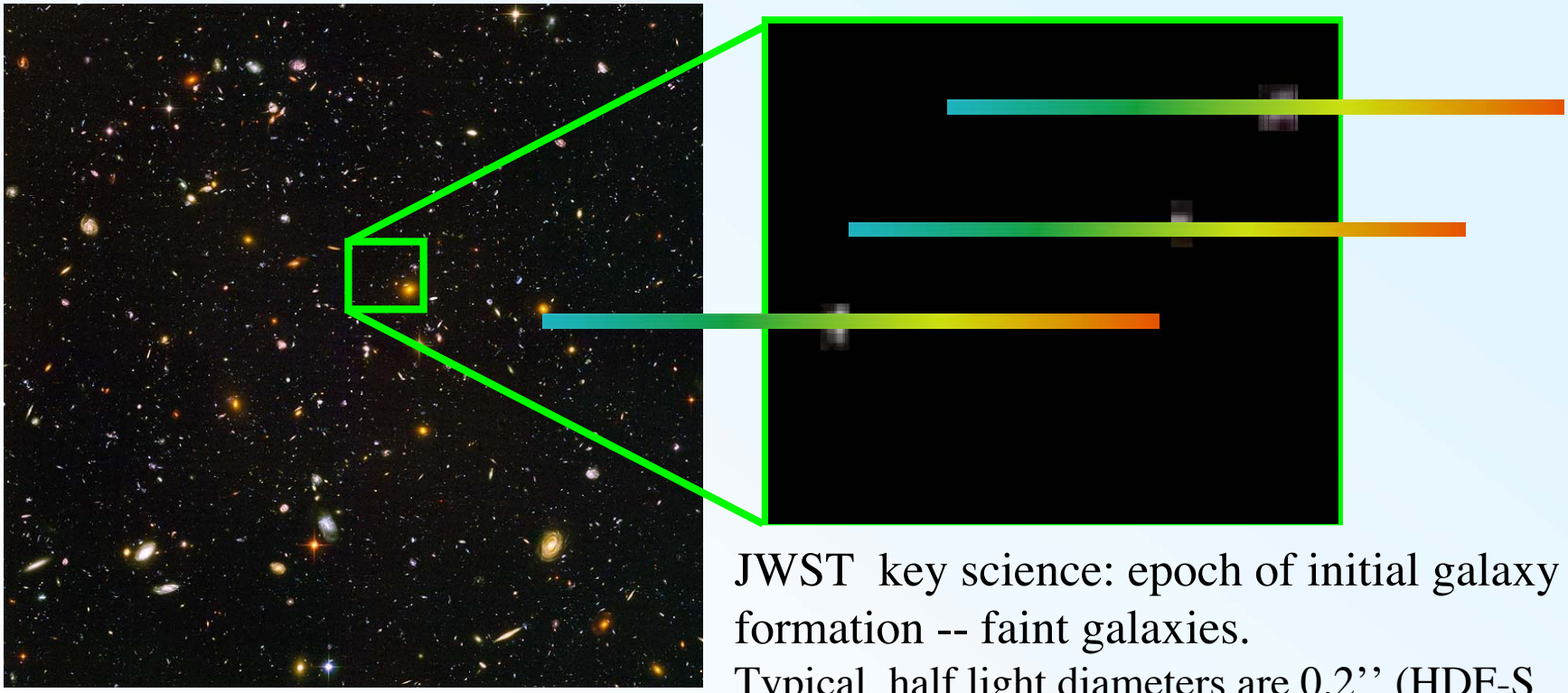
JWST NIRSpec

- **ESA has scientific and managerial responsibility for delivery of Near Infrared Spectrometer (NIRSpec)**
- **Programmable multi-object spectrometer: 342 x730 pixels - our team is developing microshutter array - 2D programmable mask, NASA contribution to the instrument**
- **0.6 - 5.5 um wavelength range**
- **Field of view 3.5'x3.5'**
- **Resolving power 100 - 1000**

Drilled Plate MOS



Hubble UDF image



JWST key science: epoch of initial galaxy formation -- faint galaxies.

Typical half light diameters are 0.2'' (HDF-S STIS image).

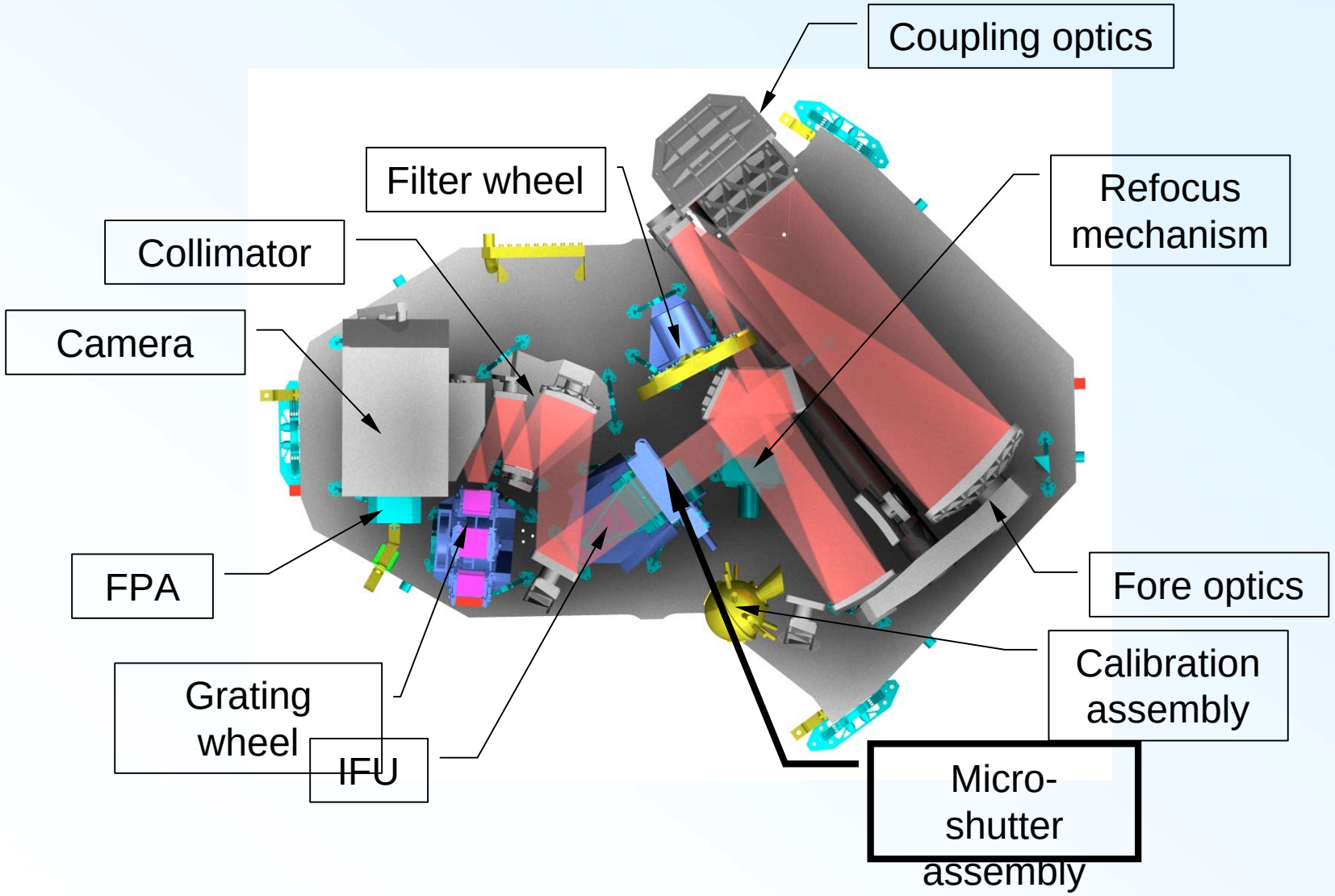
Sky is empty! At lowest isophote, 33.2 AB per $0.1''^2$ covers only 5% of sky.

Typical: > 200 galaxies at R~1000 in NIRSpec FOV

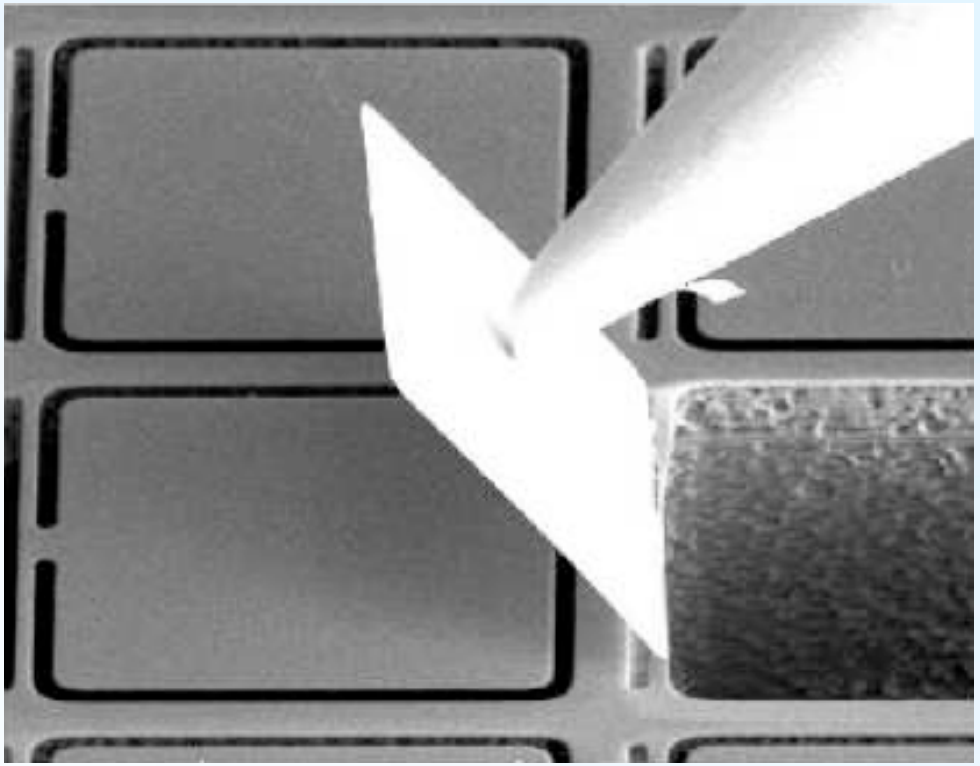
Progammable aperture mask requirements

- **Random Access Addressing**
  - Must allow the opening of any shutter distribution
    - > 200 objects simultaneously targeted
- **Must cover NIRSpec FOV (9 sq. arcmin)**
- **Individual slit size; ~ 0.2" x 0.4"**
- **Contrast**
  - Must have open to closed transmission ratio of >2000 (10,000 goal)
- **Lifetime**
  - Must operate for ~ 10^5 cycles with minimal failures
- **Must operate in the JWST environment**
  - T ~ 35 K
    - Must meet power dissipation requirements (50 mW average at 35 K)
  - Must fit envelope in NIRSpec instrument
  - Must meet mass requirements
  - Radiation - 48 kRad life dose

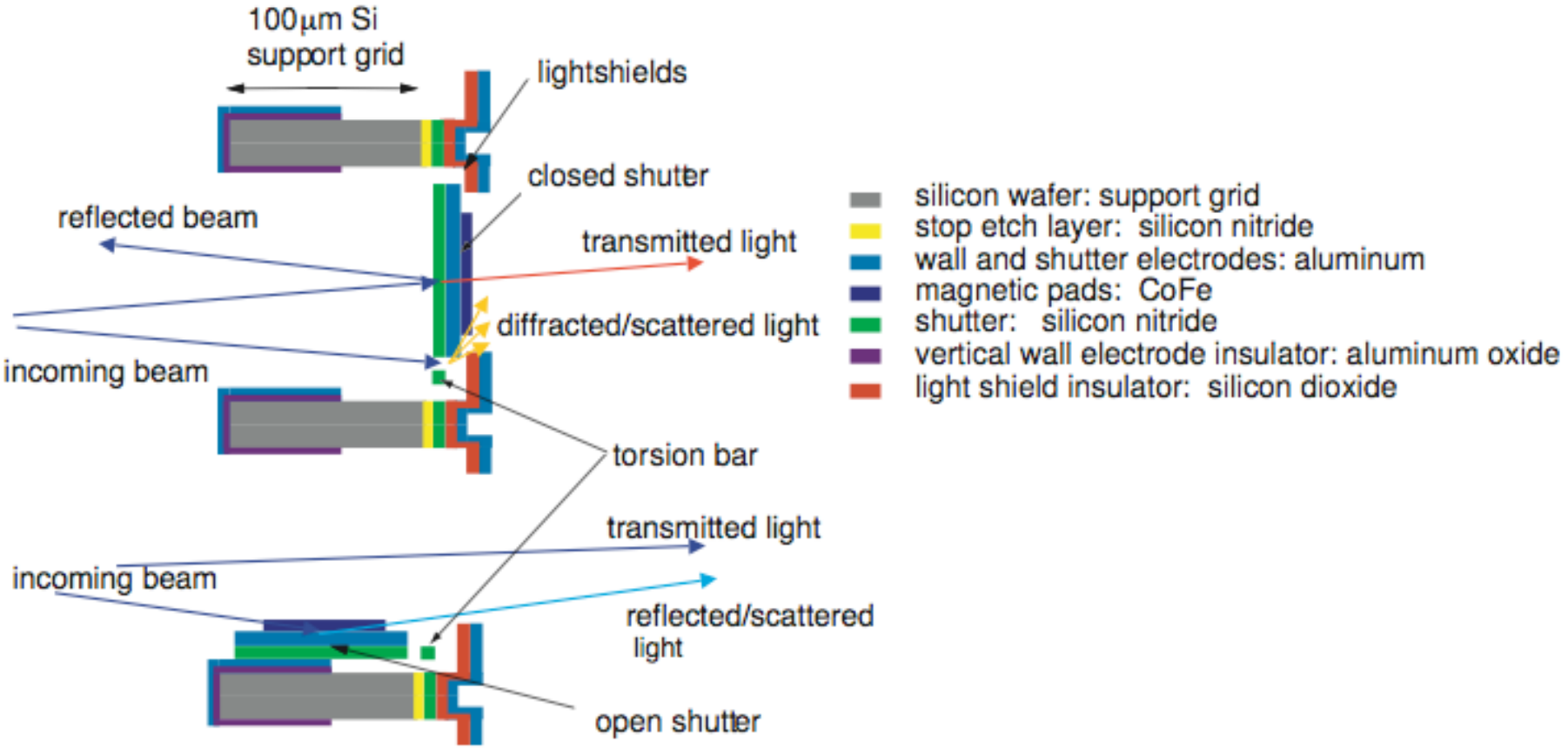
NIRSpec instrument layout



Initial concept of the Microshutter Design

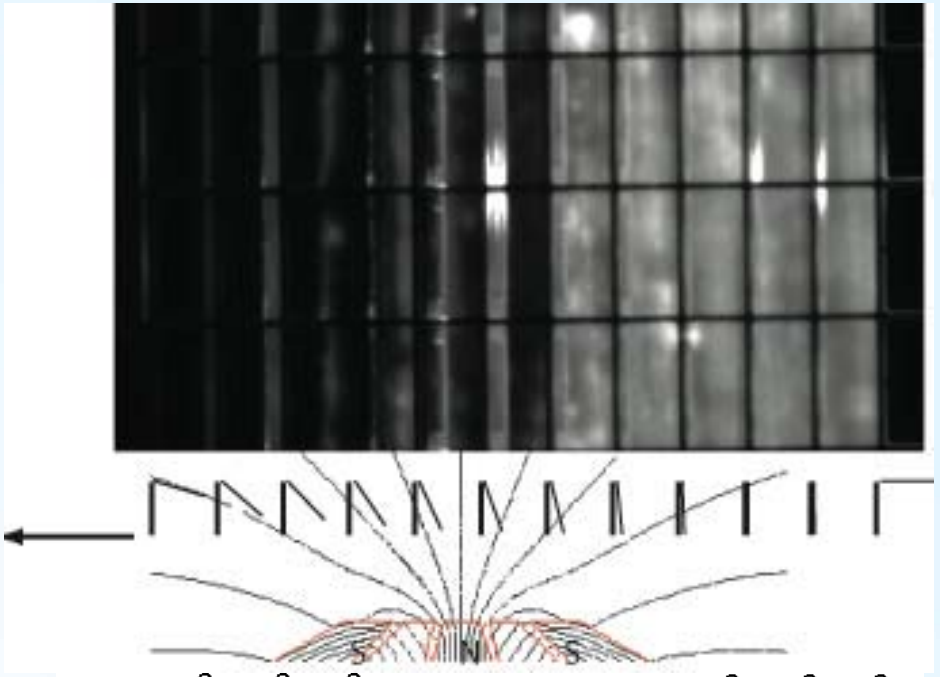


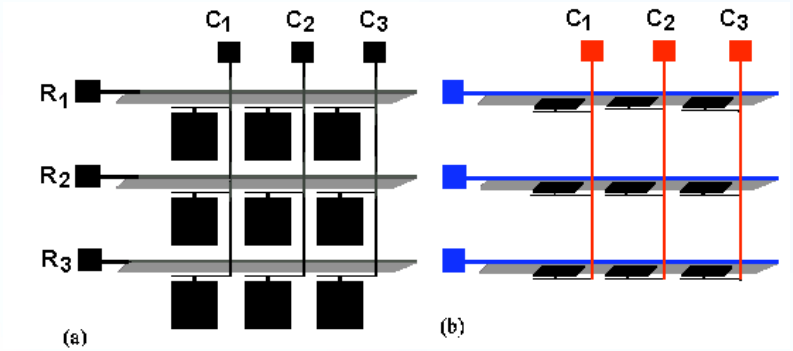
Cross Section of Unit Cell



Actuation and addressing concept

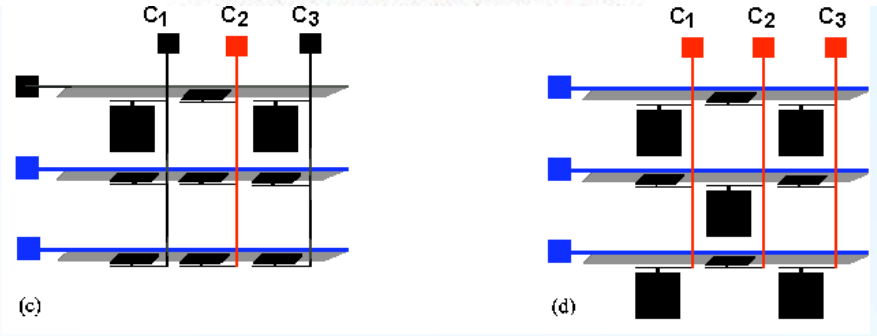
- Large displacement actuation done magnetically
  - Requires magnet scan mechanism
- Electrostatic latching and addressing
  - Crosspoint addressing requires no on-chip active electronics
- Actuation cycle: < 1 min
- Latch voltages: up to +/- 80V (+/-22V typical)





All Closed

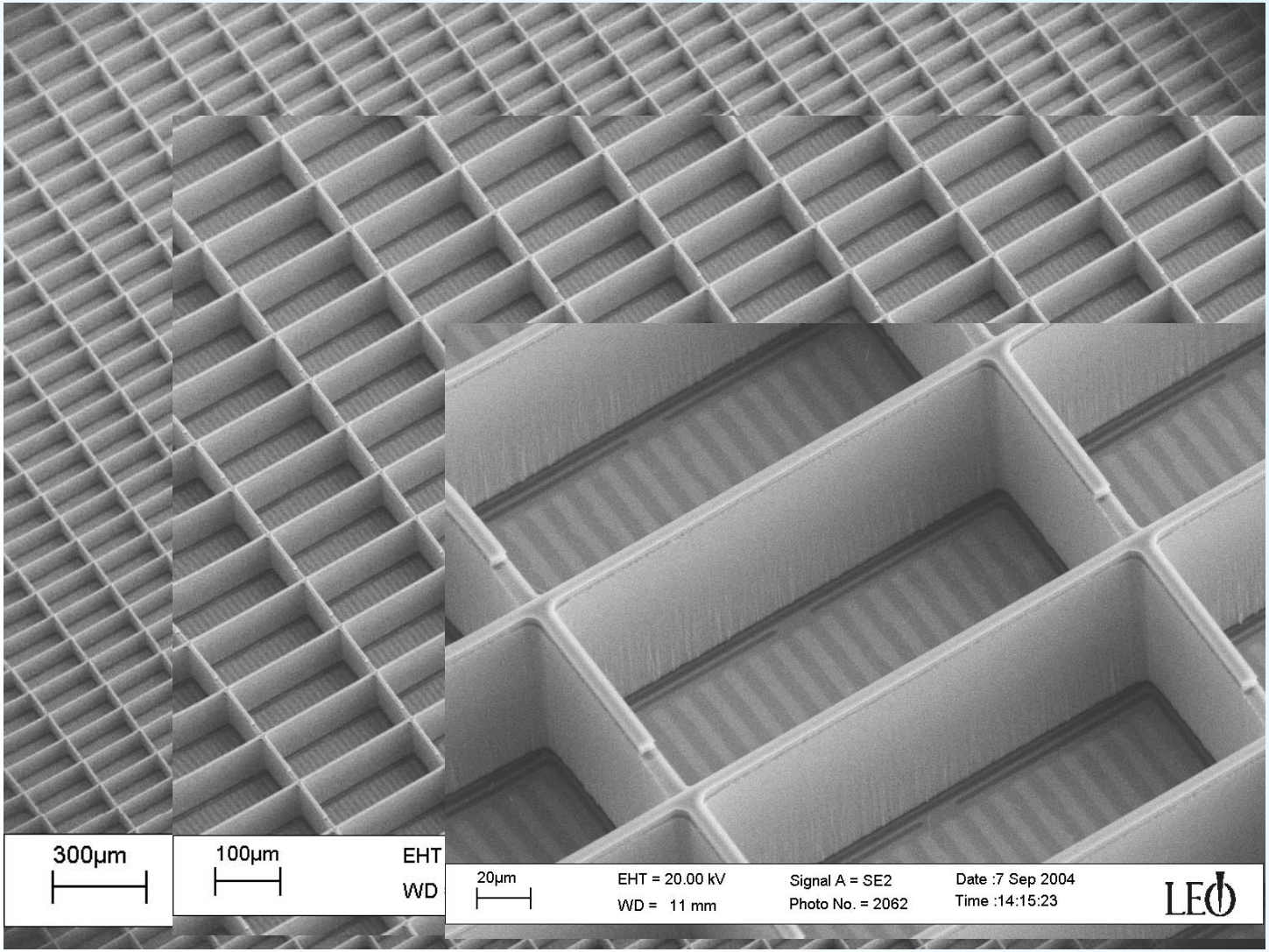
Actuate and Latch All



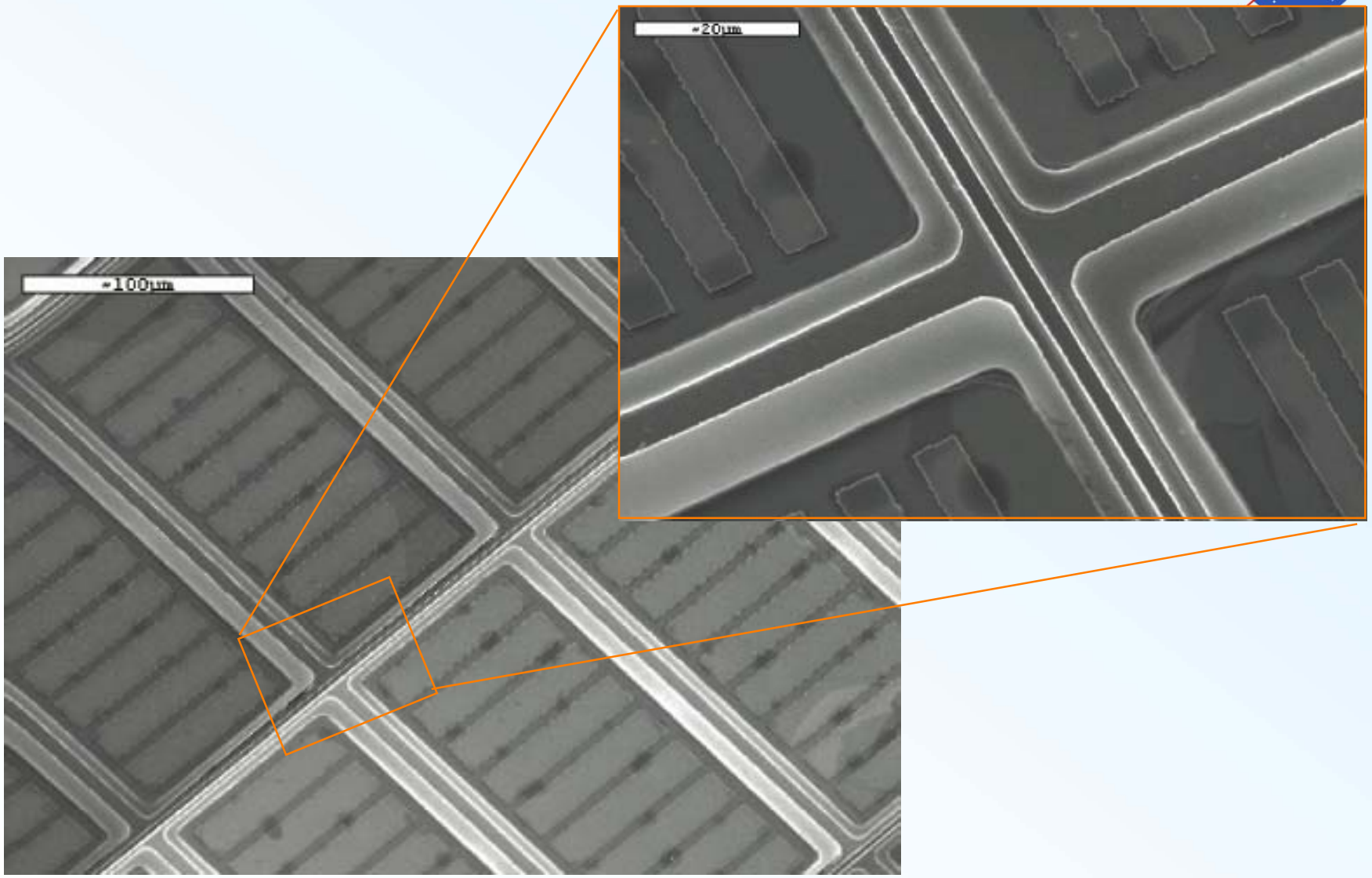
Release Selected Row 1

Hold Configuration

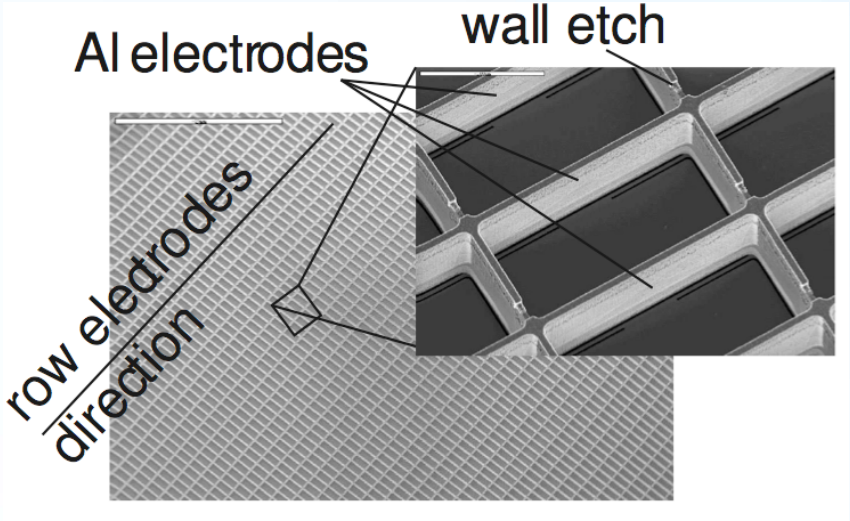
Microshutter back side - wall electrodes

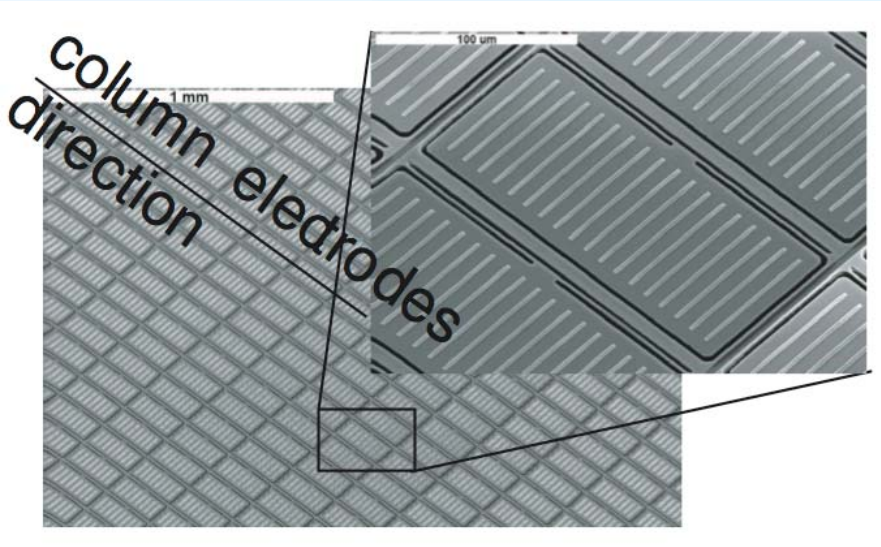


Magnetic Stripes and Light Shields



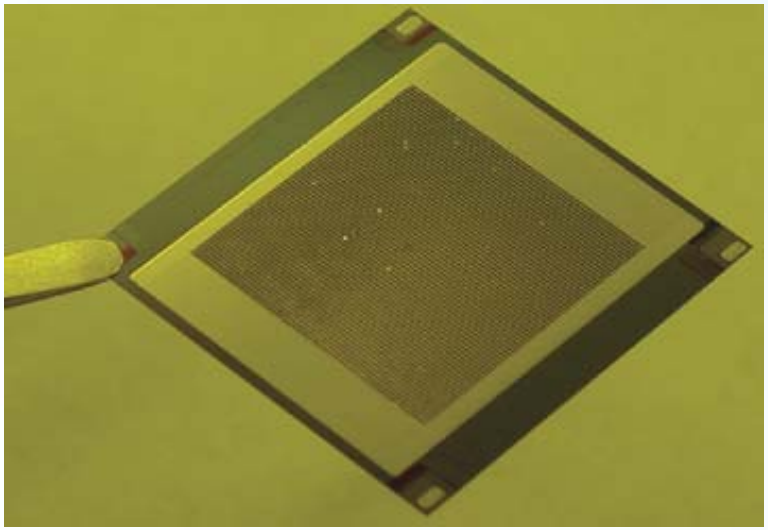
Front and back electrodes



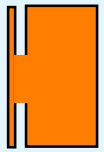


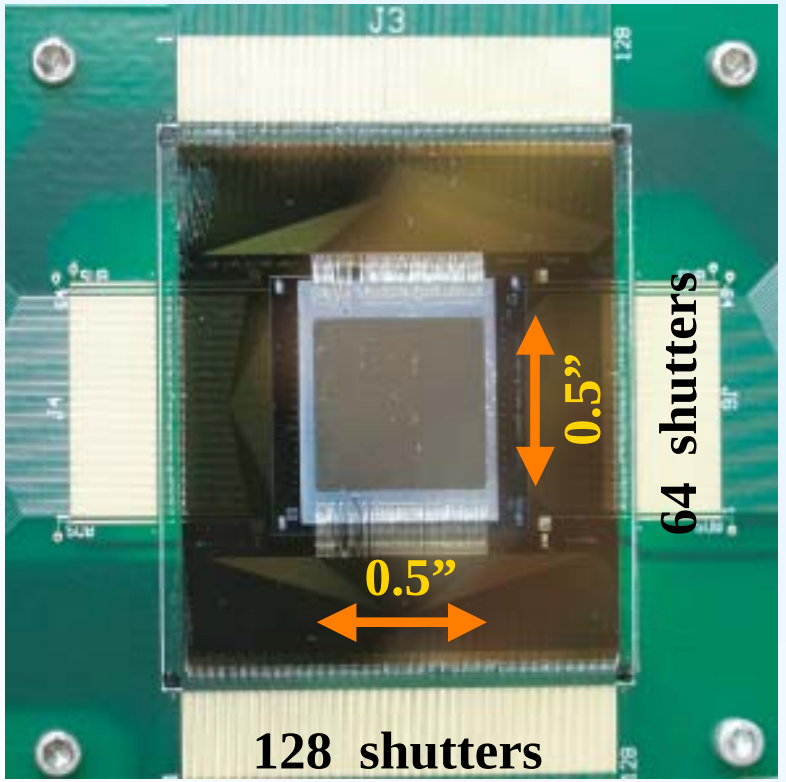
128x64 shutter array

Bare 128 x 64 array

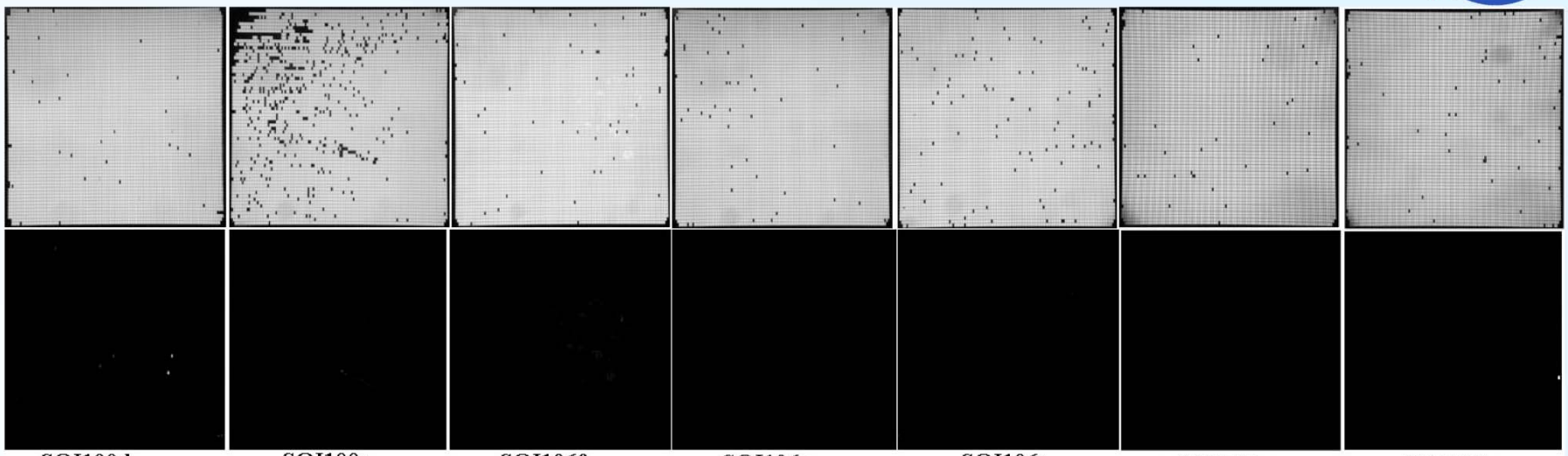


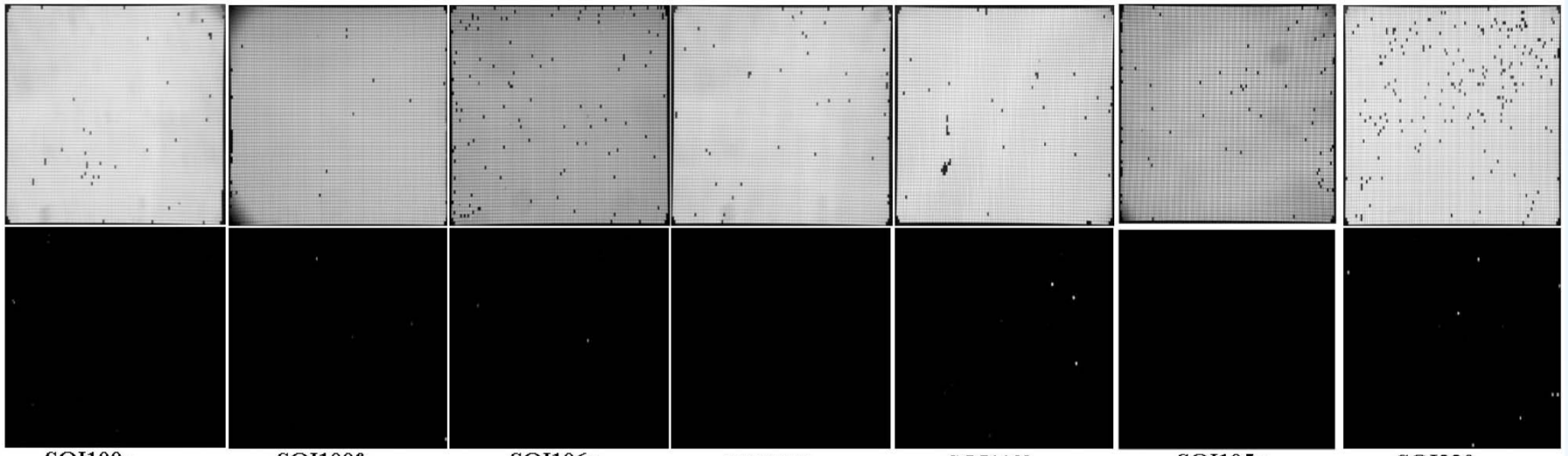
128 x 64 array bonded to Si substrate and mounted on PC board



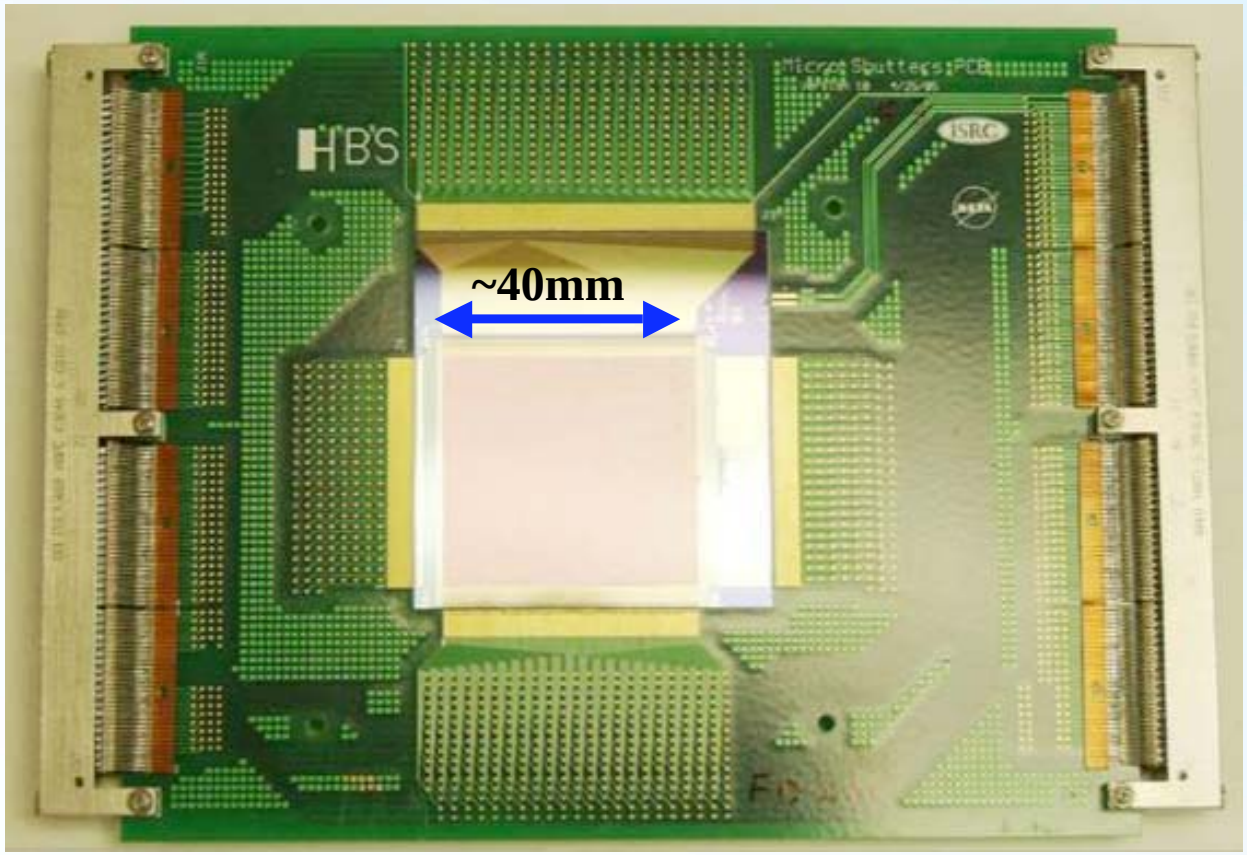


128x64 shutters actuated



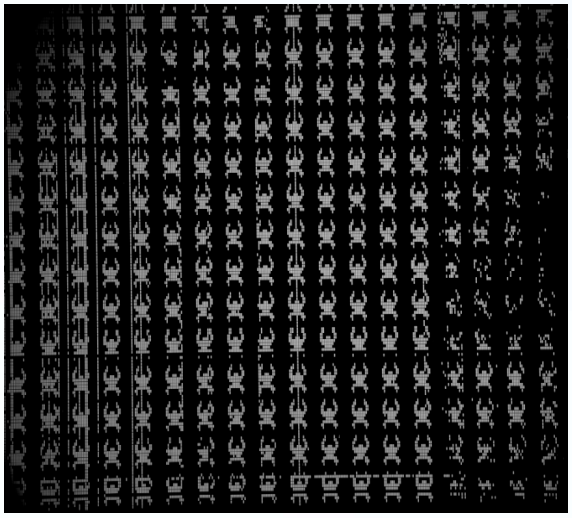


PC board mounted large format array 171x365



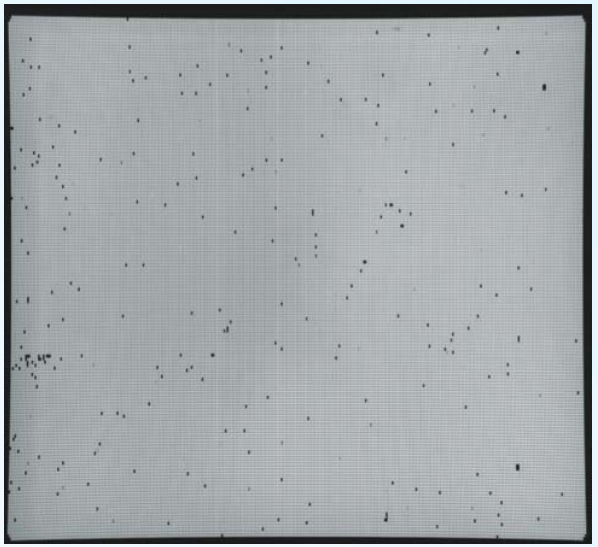
First fabricated - Aug. 2005

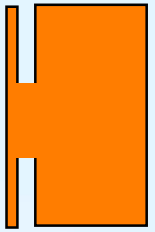
Full array addressing



365 shutters

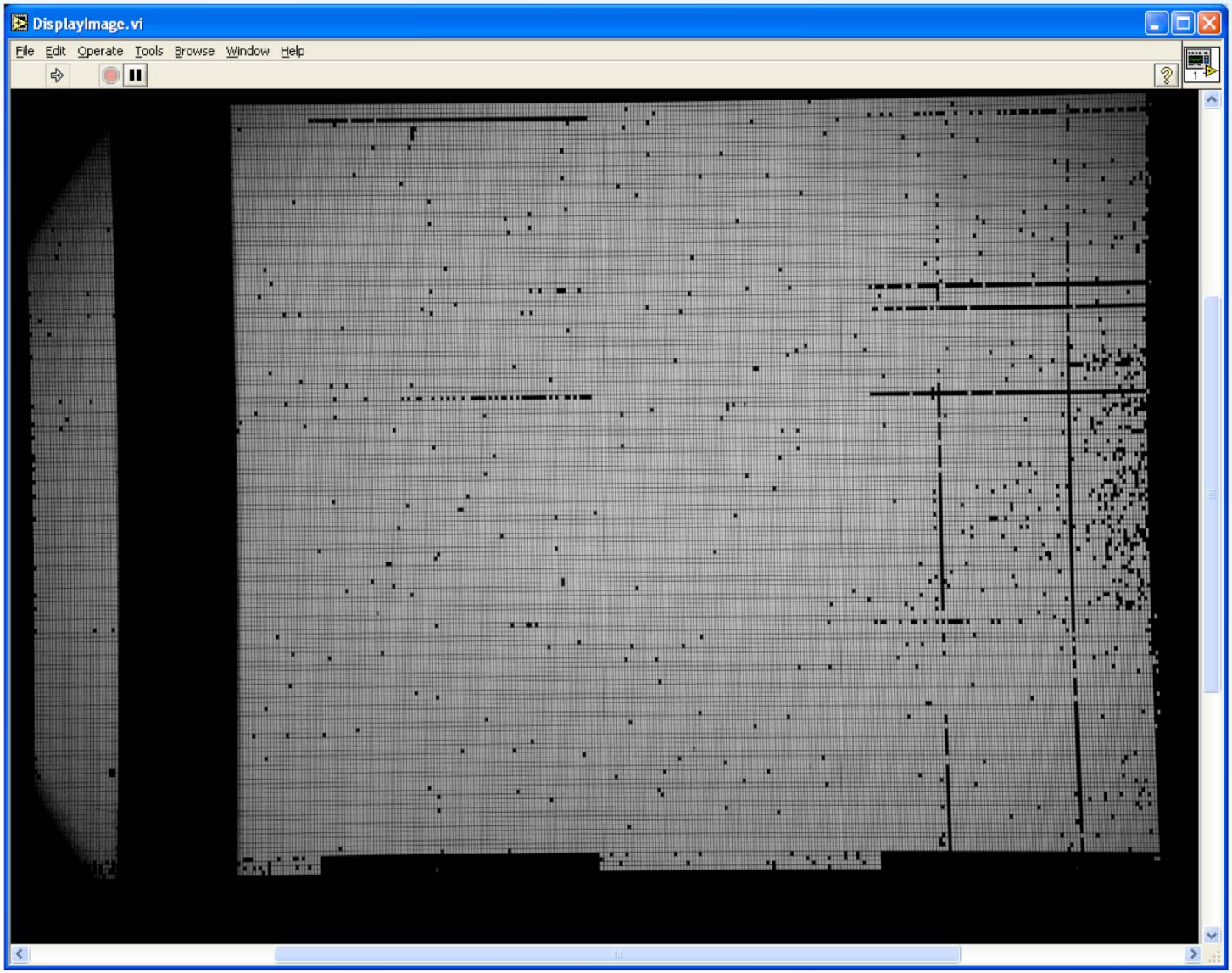
171 shutters



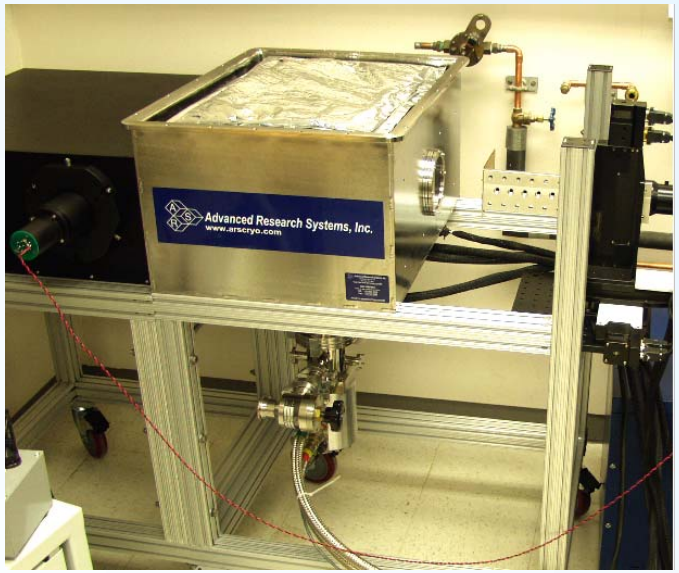


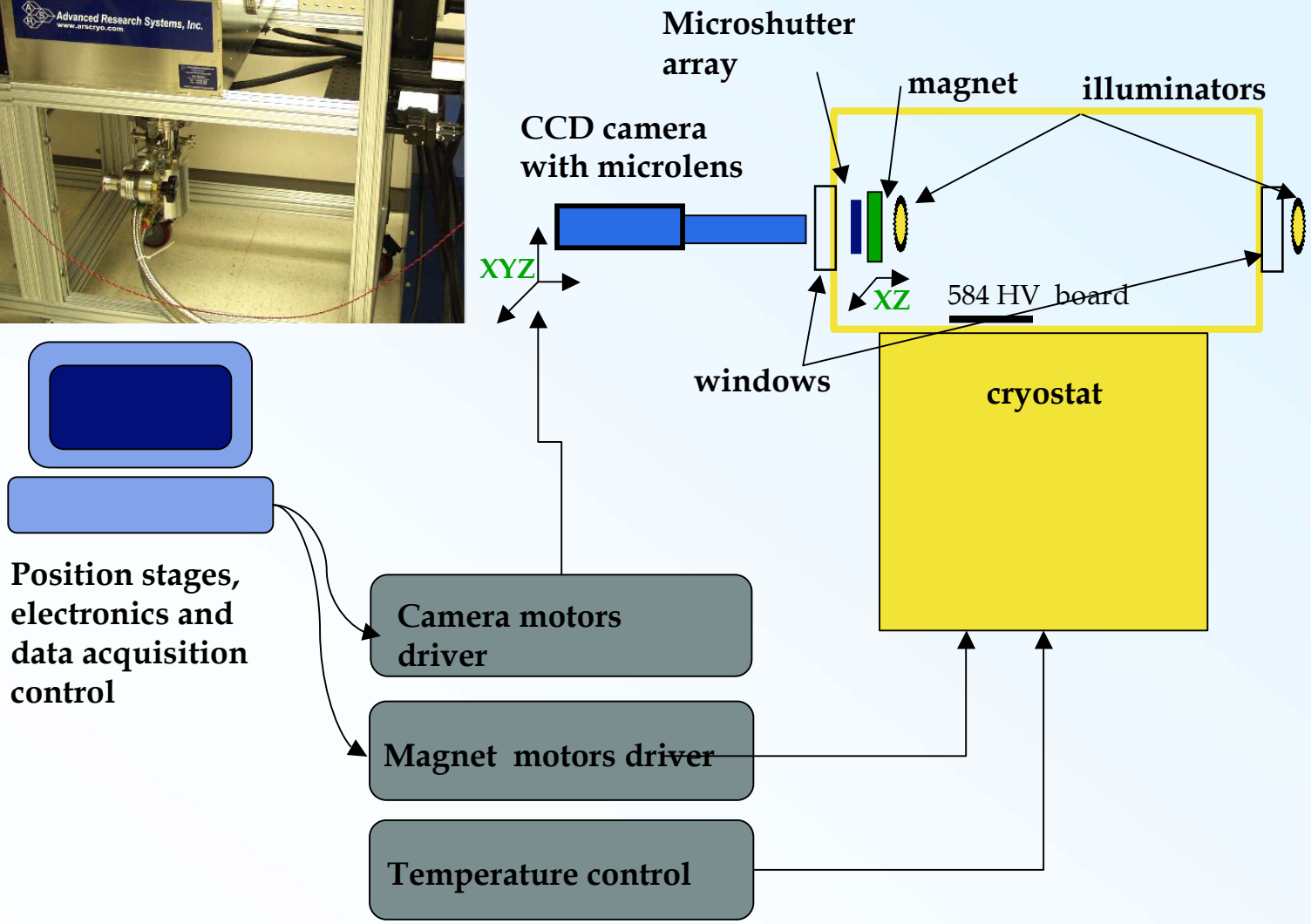
Microshutter orientation

Microshutter addressing: the movie

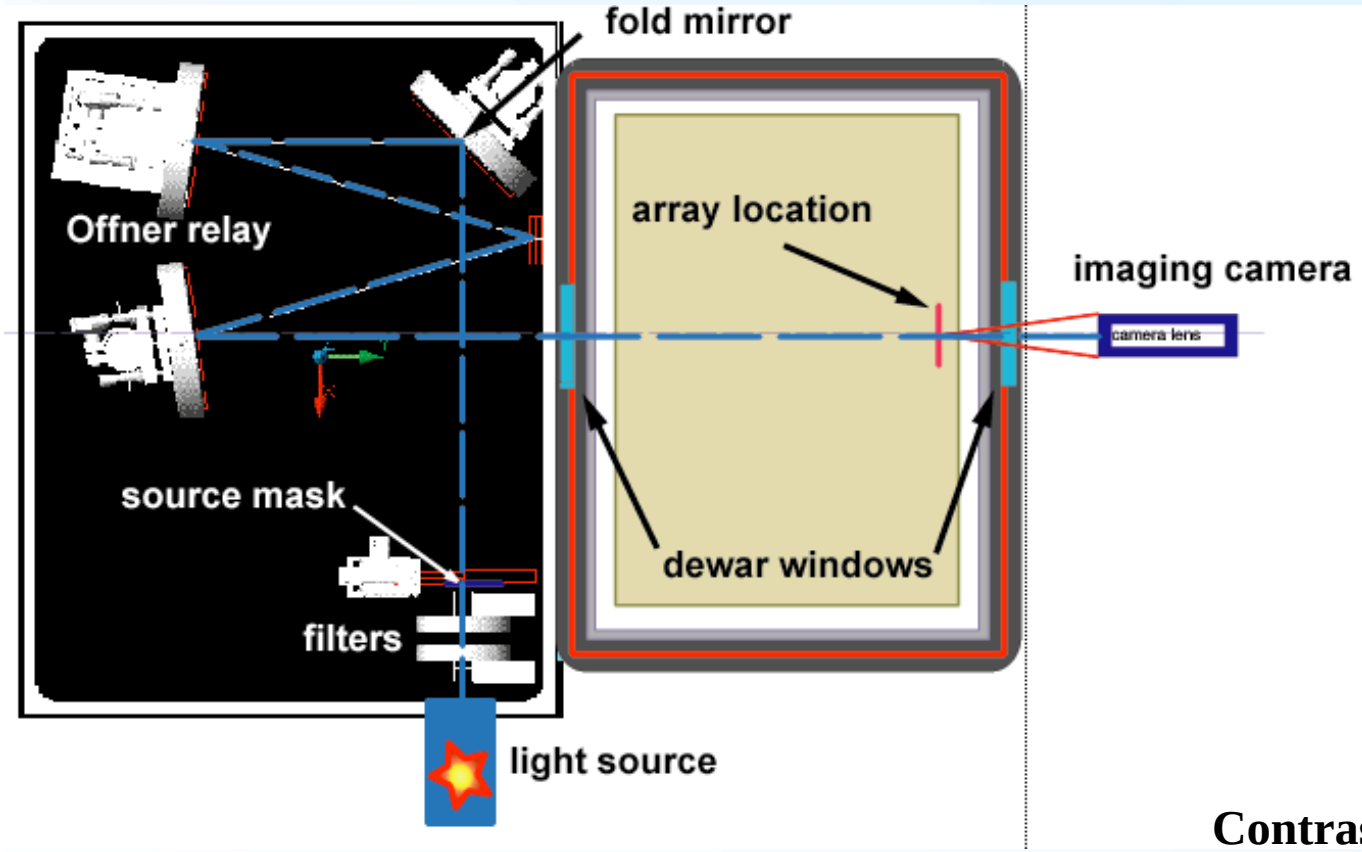


Functional test facility





Functional and optical performance

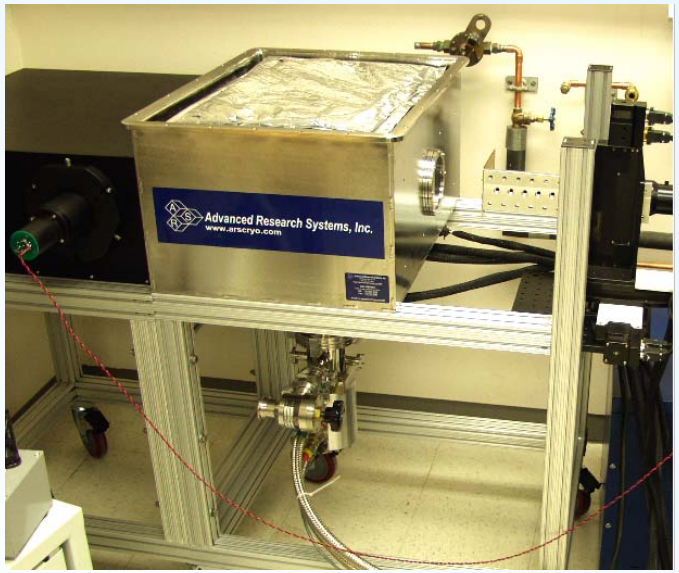


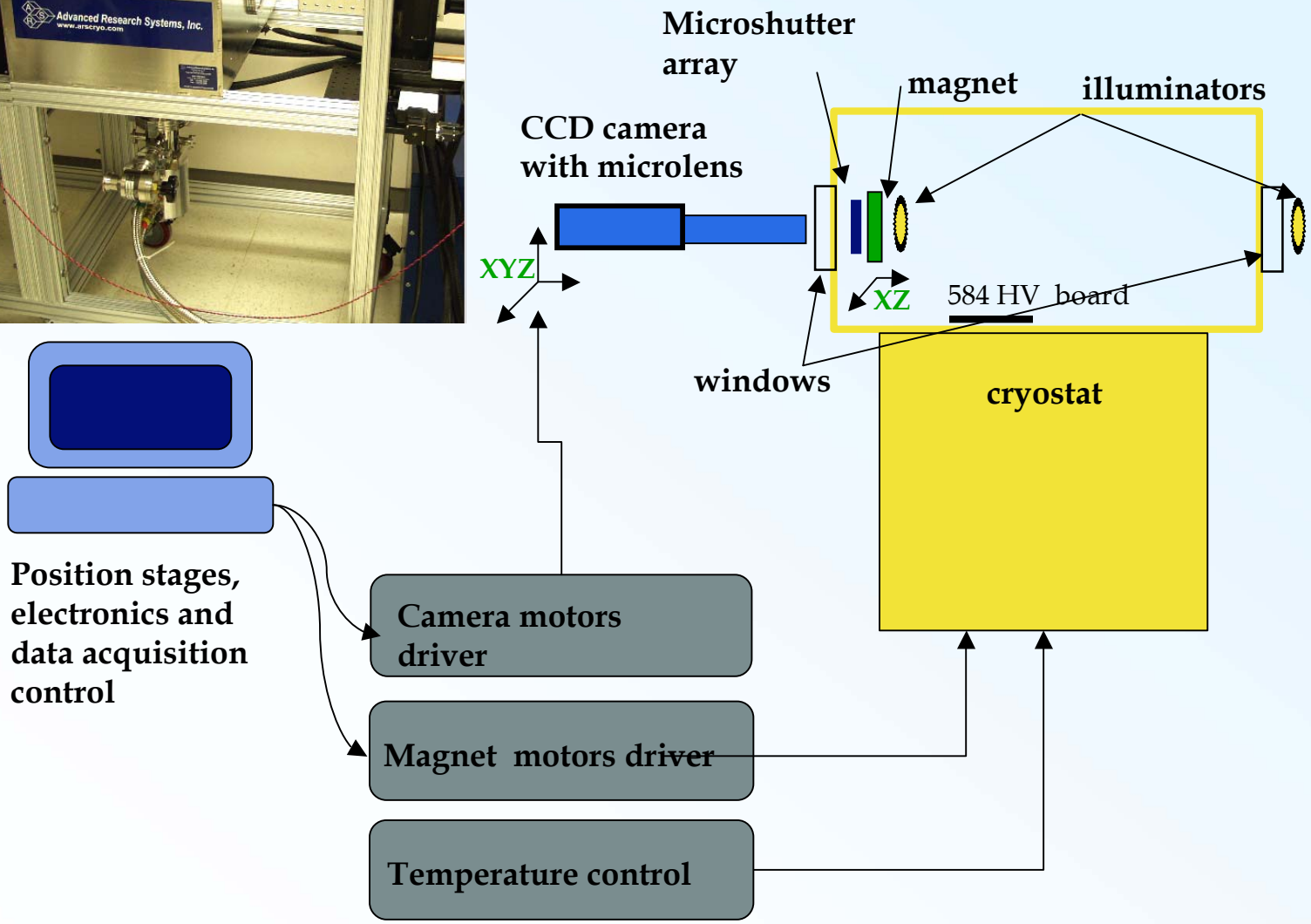
Array of source masks: from single pinhole to 17x17 pinholes (50um - 1mm)
Wavelengths: 0.6 um - 5um
Capability to measure contrast 10^4 and higher

Contrast ratio requirement:
goal: > 10^4

Measured:
Visible: 2000 - 55000
Infrared: > 2000

Functional test facility





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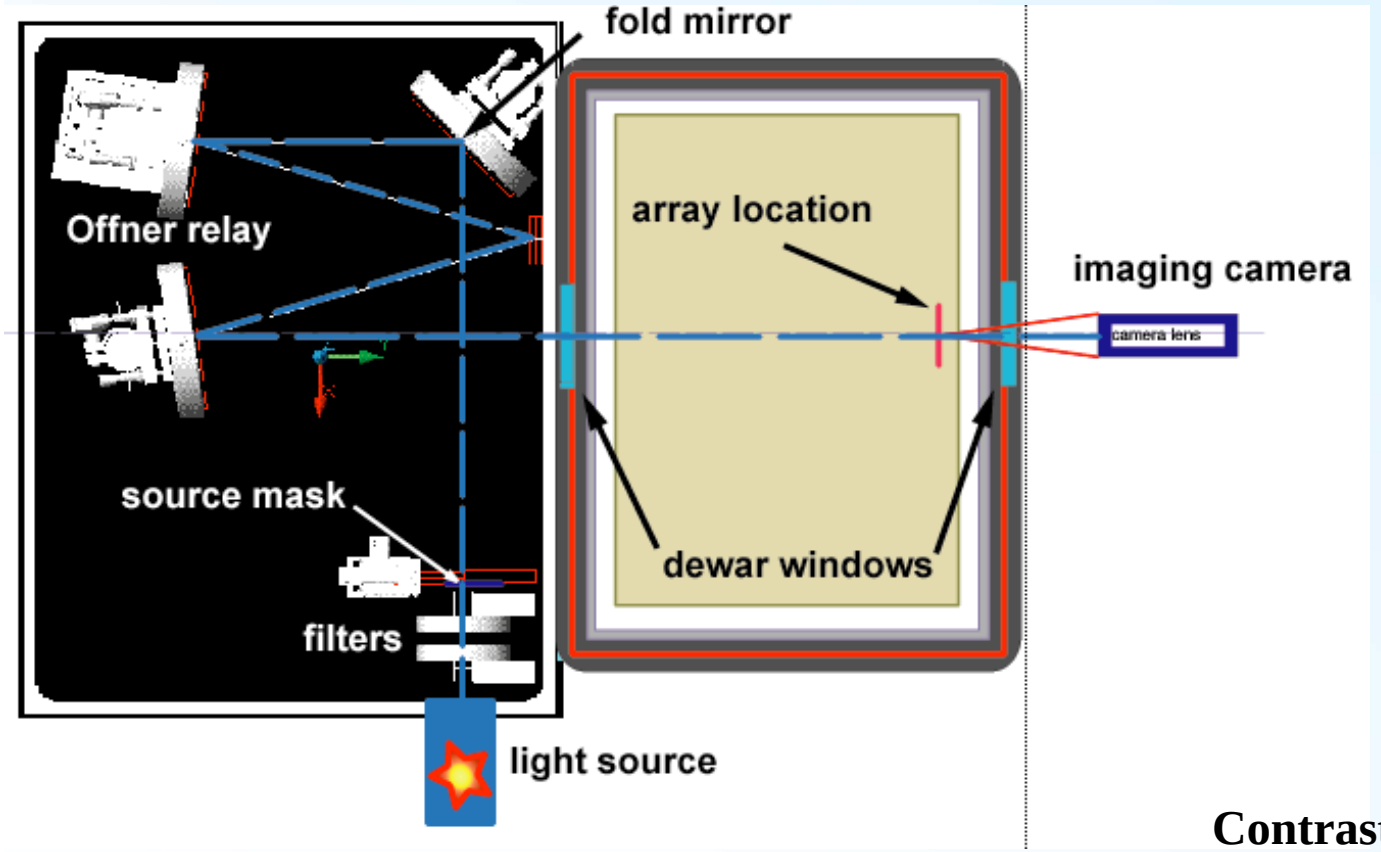

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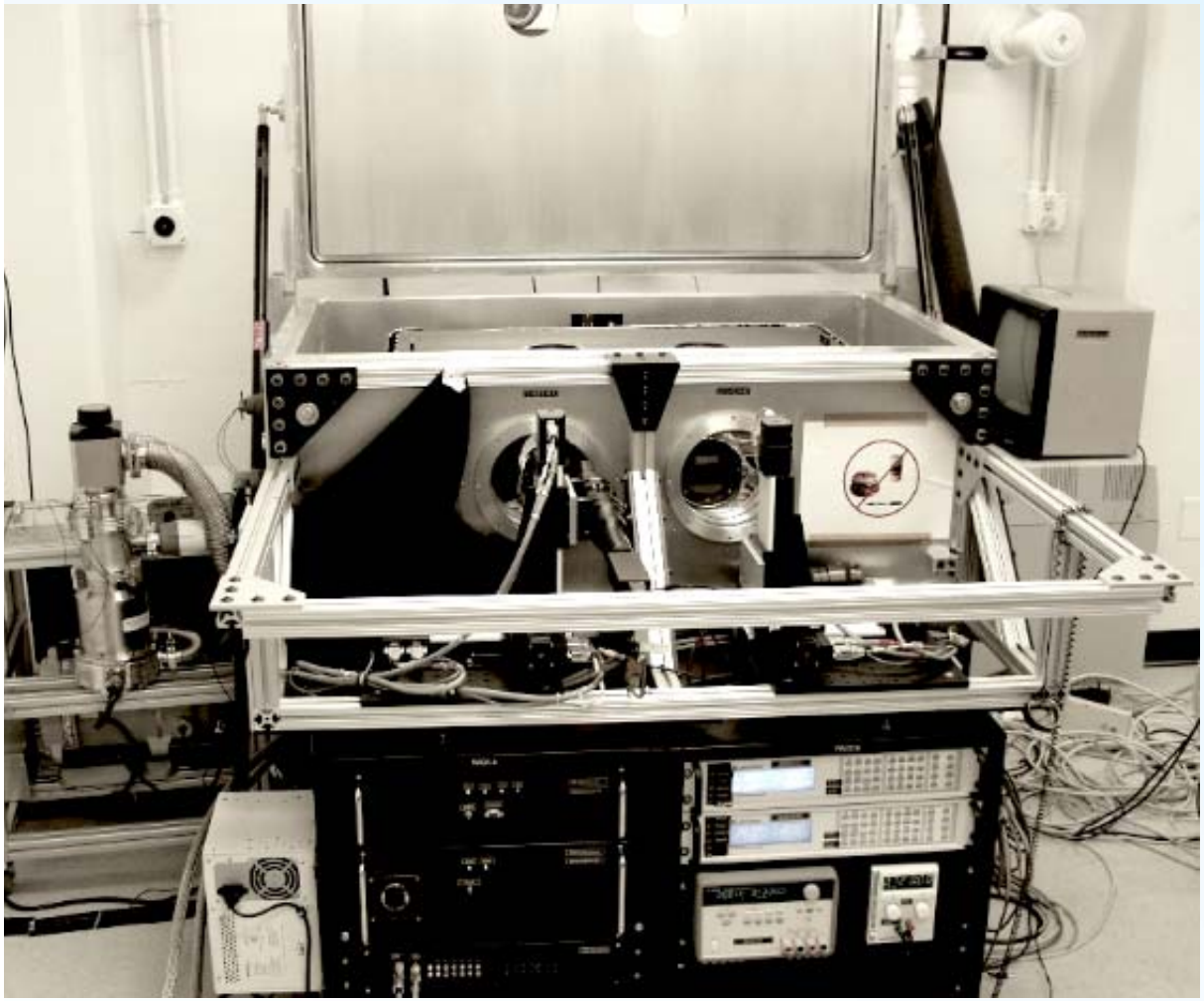
Measured:
Visible: 2000 - 55000
Infrared: > 2000

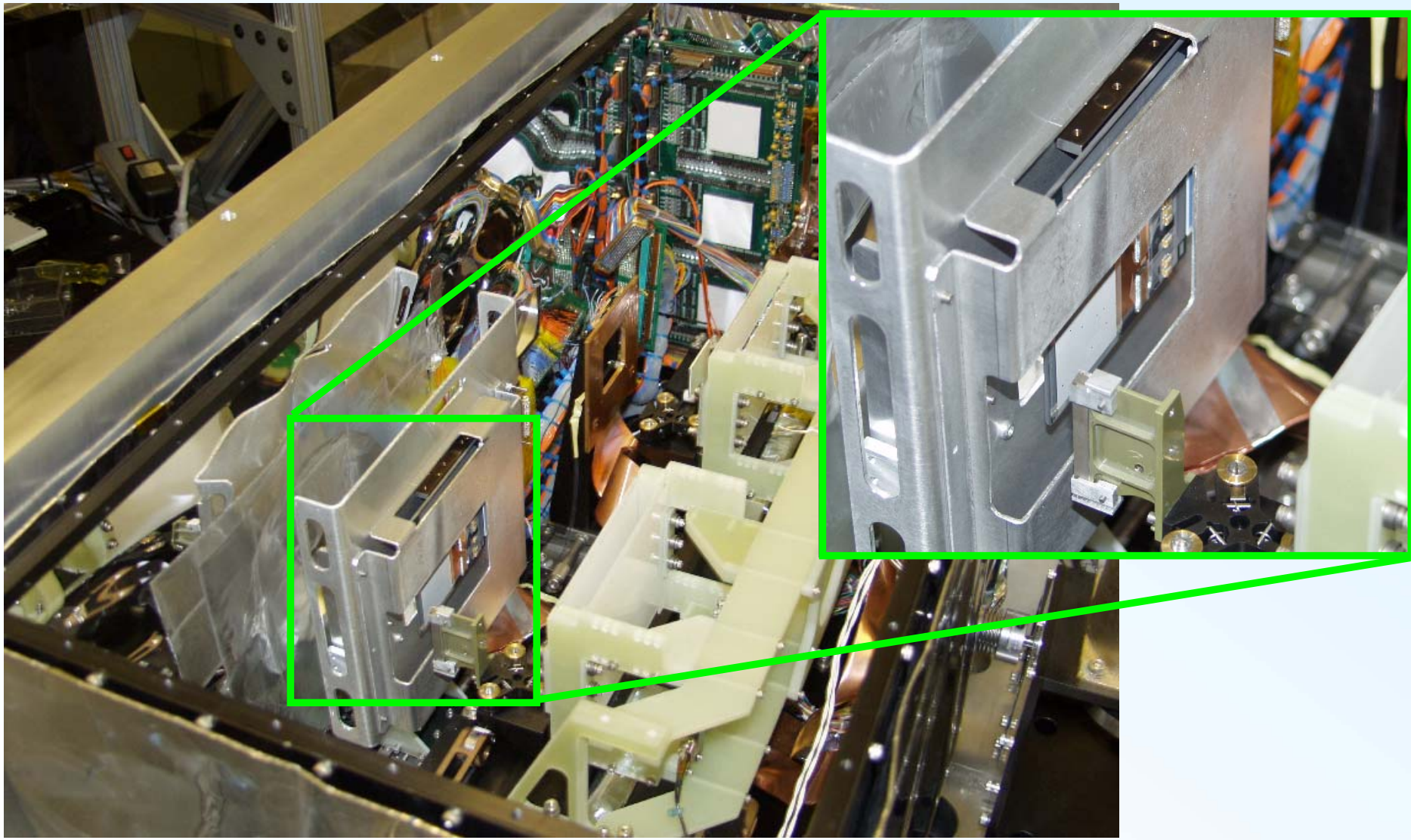
Life test facility



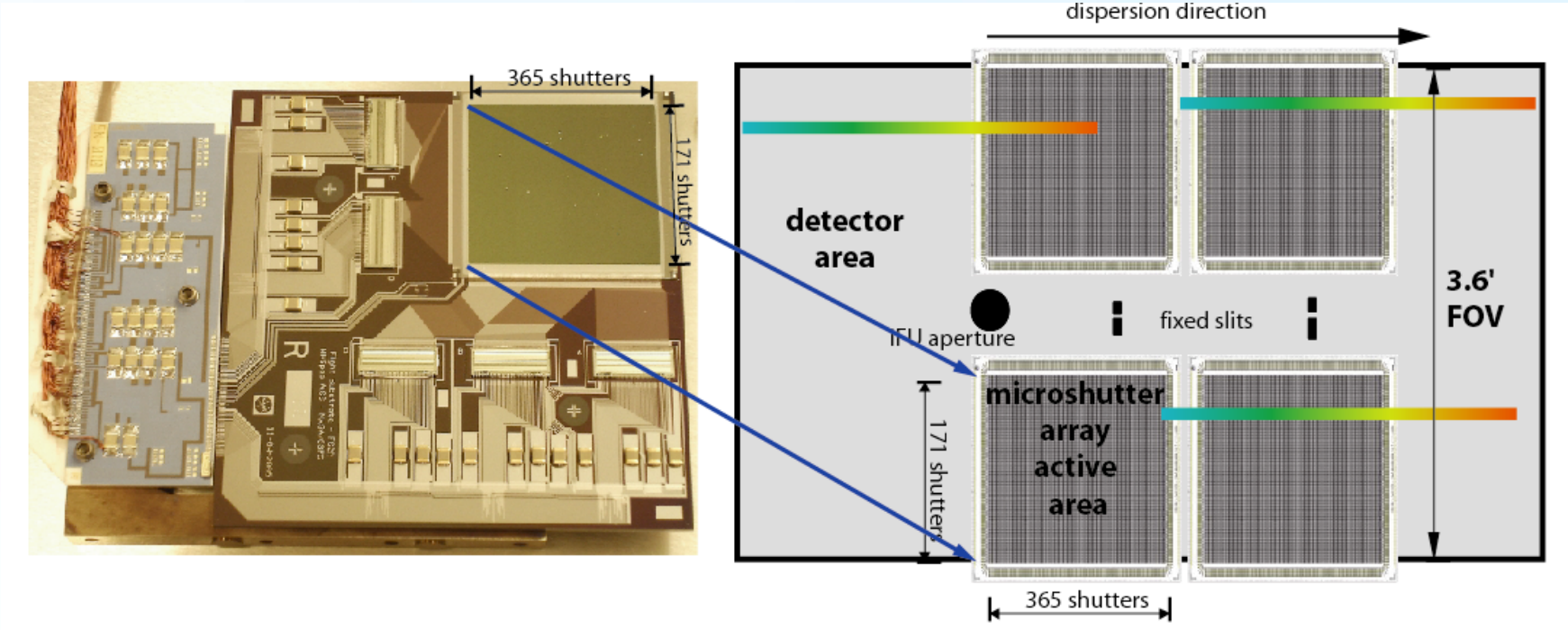
Accelerated lifetest.

- 4Hz actuation
- full 2D addressing
- both room T and cryo
- PC board and quad
- high res imaging, full array imaging

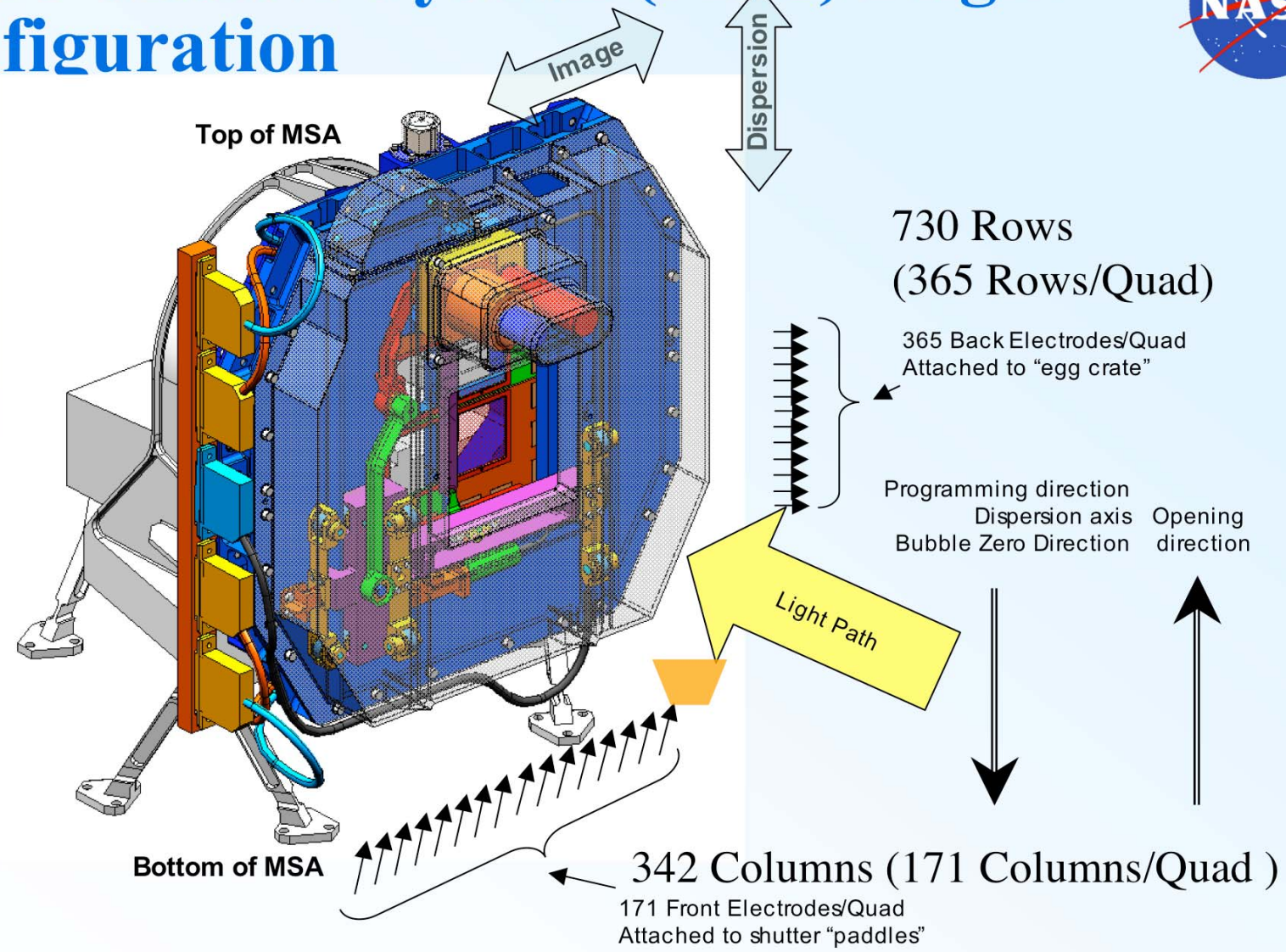
Lifetest cryostat



Microshutter array layout in NIRSpec



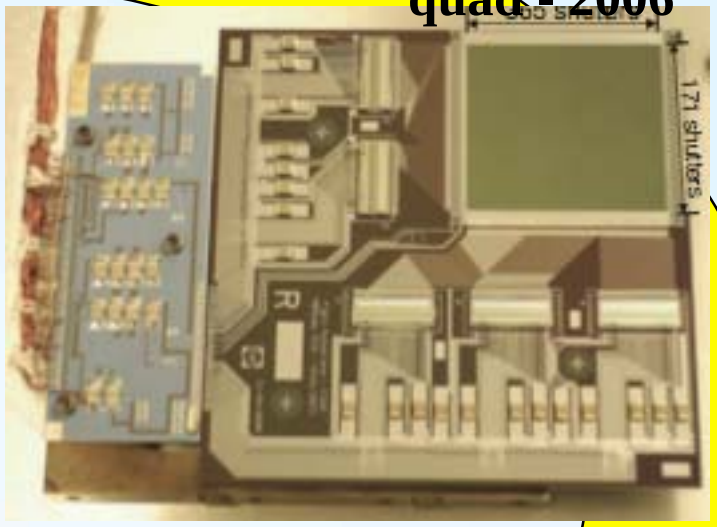
Micro-Shutter System (MSS) Flight Configuration

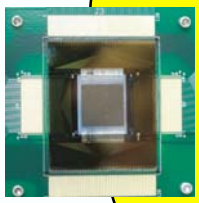


Microshutter development progress

171x365 array - 2005

First flight design quad - 2006

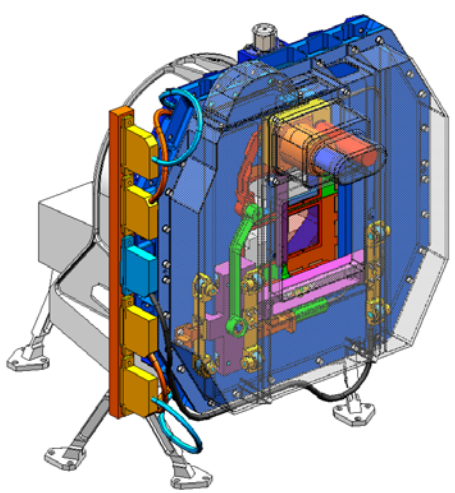




128x64 array - 2004

32x32 array - 2002

Single shutter - 1999



MSS - 2008

Summary

- **Pilot 128x64 array development completed**
- **High contrast ratio**
- **Cosmetically clean on all closed/open/addressed**
- **A number of flight format 171x365 has been fabricated and tested on PC board**
- **A first light design 171x365 QUAD array has been tested functionally (environmental testing: vibration, radiation, acoustic)**
- **TRL-6 Aug. 2006**
- **Engineering Unit 2007**
- **Delivery to ESA 2008**